Shands

UNIVERSITY OF MAINE

The Maine Agricultural Experiment Station

ORONO, MAINE

In cooperation with the Bureau of Entomology and Plant Quarantine, and the Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture

BULLETIN 480 MAY, 1950

Control of Aphids on Potatoes with DDT when Used with Fungicides

The Slosser sprayer (above) provides excellent spray coverage for potato plants.

During 3 years of experimental work DDT gave satisfactory commercial control of aphids when combined with certain fungicides, and increased the yield of potatoes at Presque Isle, Maine. The degree of aphid control and the amount of increased yield were influenced by the kind of fungicide used. The application of DDT for control of aphids had no conclusive effect upon the spread of leafroll.

The size of the aphid population that eventually developed was influenced by the fungicide and by the form and the amount of DDT applied. Larger populations of aphids developed on plants treated with tribasic copper sulfate or with nabam than on those treated with Bordeaux mixture. Fungicidal spray mixtures containing 0.5 pound of DDT in an emulsible concentrate per 100 gallons gave better aphid control early in the season than did similar mixtures containing four times as much DDT in wettable-powder form. The latter, however, proved equal or superior to the emulsion toward the end of the season. Fungicidal spray mixtures containing 0.75 pound of DDT in wettable powder per 100 gallons gave unsatisfactory aphid control.

DDT gave less effective control of the potato aphid than of any other species of aphid.

No differences of commercial importance were found, either in aphid control or in yield of tubers, from the use of 6 different solvents in making the DDT emulsible concentrates used in fungicidal spray mixtures. Some differences in yield, of minor importance, however, were found among the solvents in 1948.

Control of wingless aphids tended to be better when the emulsion spray mixture contained about five times as much of the emulsifier as is ordinarily used.

DDT, as applied for aphid control, gave satisfactory control of the Colorado potato beetle and of adults of the potato flea beetle.

Late blight was not a factor in any of these experiments.

Recommendations for the use of DDT in controlling insects on potatoes in Maine are in the Maine Extension Bulletin 361 (Revised). Copies of that bulletin may be obtained by addressing a request to your county agent or to the Maine Extension Service, University of Maine, Orono, Maine.

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ACKNOWLEDGMENTS

These studies were conducted jointly by the Maine Agricultural Experiment Station and the Bureau of Entomology and Plant Quarantine and the Bureau of Plant Industry, Soils, and Agricultural Engineering of the United States Department of Agriculture. The funds expended by the Maine Agricultural Experiment Station were derived in part from the cent-a-barrel tax under the research program approved by the Potato Tax Advisory Committee.

H. A. Jones and F. F. Smith assisted in planning some of the experiments.

R. V. Akeley, of the Bureau of Plant Industry, Soils, and Agricultural Engineering, supervised all cultural operations in the experimental plots.

The sprays were applied and the yield data were secured by P. H. Lung and P. M. Lombard in 1946, and by R. M. Cobb and P. M. Lombard in 1947 and 1948.

Others who assisted in the experiments were J. M. Williams, John Guiggey, Ruth Wentworth Gilchrist, Barbara A. Seaman, William A. Kendall, and Margaret Hanson.

Leafroll readings in Florida were made by W. F. Porter of the Maine Station and his assistants.

S. E. Northsen prepared the charts.

To all persons who contributed to this study, the authors extend thanks.

BULLETIN 480

CONTROL OF APHIDS ON POTATOES WITH DDT WHEN USED WITH FUNGICIDES

By

W. A. Shands,[1] G. W. Simpson,[2] P. M. Lombard,[3] R. M. Cobb,[4] and P. H. Lung[1, 5]

INTRODUCTION

Experiments in 1944 and 1945[6] indicated that DDT gave promise as a control for several species of aphids found on potatoes in Maine.[7] In these experiments increased yields resulted when DDT was combined with fungicides in several formulations. The results in 1945 suggested that weekly applications of DDT delayed the initial spread of leafroll in Green Mountain potatoes. At the same time, the protection from aphid and blight damage resulted in later maturity of the plants, and the data suggested that there was no reduction in leafroll spread.

The experiments reported herein were conducted to further determine the utility of DDT as an aphicide when combined with different fungicides and applied to potatoes. Criteria of effectiveness in all experiments included plant appearance, aphid population trends, yield of tubers, and also leafroll spread in three of the experiments.

Experiment 1 was designed to determine the effects of weekly ap-

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[1] Entomologist, U. S. Dept. Agr., Agr. Res. Adm., Bur. Ent. and Plant Quarantine.

[2] Associate Entomologist, Maine Agr. Exp. Sta.

[3] Horticulturist, U. S. Dept. Agr., Agr. Res. Adm., Bureau Plant Industry, Soils, and Agricultural Engineering.

[4] Agent, U. S. Dept. Agr., Agr. Res. Adm., Bur. Ent. and Plant Quarantine, and Assistant in Entomology, Maine Agr. Exp. Sta. Associated with the work done in 1947 and 1948.

[5] Associated with the work done in 1946.

[6] Bronson, T. E. Insecticide tests on small plots. Annual report of progress. Maine Agr. Expt. Sta. Bul. 438:524. 1944.

Bronson, T. E., Smith, F. F., Shands, W. A., and Simpson, G. W. Control of aphids on potatoes and the spread of leafroll. Annual report of progress. Maine Agr. Expt. Sta. Bul. 442:134-138: Smith, F. F., and Lombard, P. M. Annual report of progress. Maine Agr. Expt. Sta. Bul. 442:138-140. 1945.

Bronson, T. E., Smith, F. F., and Simpson, G. W. Control of aphids on potatoes in northeastern Maine. Jour. Econ. Ent. 39:189-194. 1946.

[7] The green peach aphid, *Myzus persicae* (Sulz.); the buckthorn aphid, *Aphis abbreviata* Patch; the potato aphid, *Macrosiphum solanifolii* (Ashm.) and the foxglove aphid, *Myzus convolvuli* (Kltb.) = *pseudosolani* Theob.

plications of spray mixtures made with two fungicides and of similar mixtures to which DDT was added. The fungicides were Bordeaux mixture and tribasic copper sulfate. DDT as a wettable powder and as an emulsible concentrate were combined with each of these fungicides.

Experiment 2 was undertaken to measure any differences in the effectiveness of DDT when applied as a wettable powder in each of the three fungicides Bordeaux mixture, tribasic copper sulfate, and nabam. A uniformly reduced concentration of DDT was used in all mixtures so as to accentuate any effects of the several fungicides. A fourth treatment was included to determine what effect a spreading agent might have upon the aphicidal value of DDT when applied with Bordeaux mixture.

Experiment 3 was conducted to determine whether varying the amount of emulsifying agent in the emulsible concentrate of DDT would influence the effectiveness of DDT as an emulsion when applied with each of the three fungicides used in Experiment 2.

Experiment 4 was designed to determine whether the effectiveness of DDT, applied as an emulsion with a fungicide, might be influenced by the kind of solvent used in preparing the DDT emulsible concentrate. The fungicide for all mixtures was yellow cuprous oxide.

PROCEDURE

Cultural Practices in Experimental Plantings

Three experiments were carried out in 1946 and an additional 1 in 1947 and 1948 on small, replicated plots of potatoes in Aroostook County, Maine. Fertilization (1 ton of 6-9-12 per acre in 1946 and of 5-7-10 in 1947, and 1,500 pounds of 8-16-16 in 1948), and other cultural procedures were those commonly practiced in growing potatoes in this area.

Plots not treated with DDT in 1946 received 2 applications of calcium arsenate for the control of the Colorado potato beetle. The only other insecticides and the only fungicides applied were those included as treatments in the experiments.

In 2 of the experiments (Nos. 1 and 4) strips of oats were grown in the alleys between blocks and columns of plots to serve as barriers to aphid movement, but this was not done in the other 2 experiments. The oats were planted at 2 different times. The first seeding, in the alleys between columns of plots, was made when the potatoes were planted on May 15, in 1946, on May 23, in 1947, and May 10, in 1948. The second seeding, in alleys between blocks of plots, was made immediately after the final cultivation and hilling of the potatoes early in

July in 1946 and 1947. No second seeding of oats was made in 1948, as in this year all alleys were sown when the potatoes were planted.

The alleys between columns of plots were 9 feet in width in experiment 1 and 5 feet in experiment 4, while those between blocks were 20 to 23 feet to allow room for the turning of the tractor carrying the sprayer. There were no alleys between columns of plots in experiments 2 and 3, and those between blocks of plots were kept bare fallow. General views of the potato plots in 1946, experiment 1, with strips of oats separating each are shown in Figure 1, A and B.

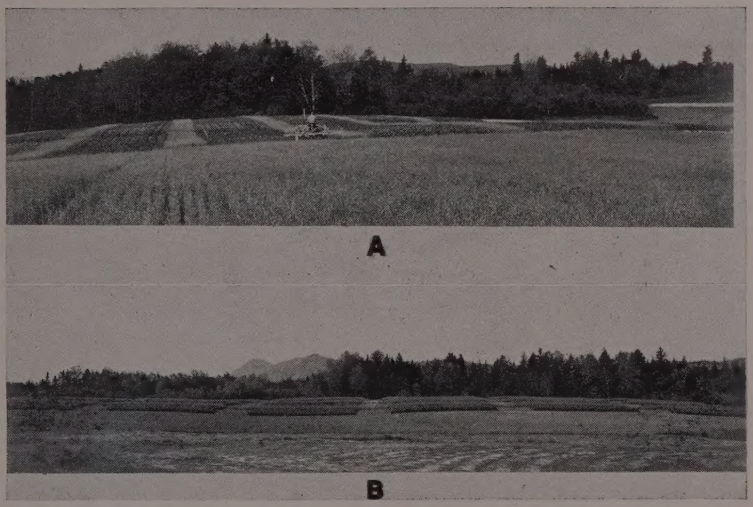


FIGURE 1.—Potato plots in Experiment 1: A, Oats growing between columns of plots; B, oats growing between blocks of plots.

MACHINERY AND RATE OF APPLICATION OF SPRAY

Spray mixtures were applied in all 4 experiments. The same spray machine was used for applying all mixtures. The spray nozzles of this machine, designed by J. W. Slosser[8] of the Soil Conservation Service, U. S. D. A., cover 5 rows of potatoes. It is equipped with 5 independent boomlets instead of a single conventional boom. Each boomlet, equipped with 4 nozzles, rides on a specially designed skid which slides over the surface of the soil between rows. Of the 4 nozzles 2 are directed down-

[8] Slosser, John W. An improved sprayer boom for potatoes and other row crops. Agr. Eng. 26:453-455. 1945.

ward and out, and 2 upward and out. The 2 directed upward and out are fixed behind a specially designed vine lifter in such a way that they direct spray to the under sides of the potato leaves. In tests covering several years, this machine has been found capable of providing better plant coverage and better aphid control, especially on the lower parts of a potato plant, than has been obtained by the conventional spray machines generally used in the area.

The tractor drawing the sprayer was driven, when applying the sprays, at about 3 miles per hour. A pressure of 100 to 120 pounds per square inch was maintained, and the spray was delivered at about 125 gallons per acre.

SOURCES OF INGREDIENTS OF SPRAY MIXTURES

The aphicides included in these experiments were applied in conjunction with fungicides. The fungicides used were among those commercially available. The DDT wettable powders were commercial preparations containing 50 percent of DDT. A fresh supply was purchased each year. The supply of emulsible concentrates of DDT used in the experiments in 1946 was specially prepared by F. F. Smith. All but 1 of the emulsible concentrates of DDT included in the experiment of 1947 and all of those included in 1948 were specially prepared by R. J. Prentiss and Company, Inc., in accordance with specifications supplied to them. The emulsible concentrate containing xylene in 1947 was prepared by 1 of the authors. The wetting-spreading agent included in 1 of the treatments in 1946 was a commercial preparation known as Santomerse-D.

APPLICATION OF SPRAY MIXTURES

All spray mixtures were prepared in the tank of the sprayer just before they were applied. The DDT preparations were added as the last few gallons of water were being run into the tank. In the 1946 experiments, in order to cover the 9 rows in each plot, 2 nozzles were plugged shut on one outside boomlet and the machine was driven down and back through the field for each treatment. In this way 4 rows and 1 side of the fifth were covered on each trip. In the 1947 and 1948 experiment, since each plot had only 4 rows, the sprayer was reduced to a 4-row outfit by plugging 2 nozzles on both outside boomlets.

MEASUREMENTS OF EFFECTIVENESS OF TREATMENTS

Several criteria were used in determining the effect of the treatments. In 1946 frequent observations were made of the growing plants,

frequent counts were made to determine the size of aphid populations on the plants, and tuber samples were taken to determine yield and the spread of leafroll.

In 1947 and 1948, observations were made of all plots at the time the spray mixtures were applied, when aphid counts were made, and at least once more each week to determine whether the different solvents had any effect on the plants. In addition to plant appearance the notes included observations upon plot-to-plot differences in the size of the plants, the time when flowers first appeared, the number of flowers, the duration of the flowering period, the formation of seed balls, the amount of leaf-tip burning, and the prevalence of purple top.

Aphid populations in the various plots were determined by identifying and recording, by species, the number of winged and wingless aphids found on stratified foliage subsamples of 25 sample plants taken at random from a centrally located sample portion of each plot. The number of sample units (plants) and the size of the subsample units varied from count to count depending upon the size of the aphid population. Early in the season, when small numbers of aphids were present, an entire leaf in each of 3 positions on each sample plant was the unit of subsample. These 3 leaves were randomly located within the top, middle, and bottom thirds of the plant. This has been found necessary to insure an adequate sampling of the 4 species of aphids infesting potatoes, because each species of aphid has a different distribution on the plant. Later, when larger aphid populations were found, the leaf area observed was reduced to include only the terminal and 2 basal leaflets (leaflets 1, 4, 7) of a leaf in each of the standard positions on each sample plant. When still larger numbers were present, the subunits were further reduced to only half the area of these 3 leaflets in similar positions. All the leaf area on one side of a midrib of a leaflet constituted a half leaflet. Previous studies have shown that this is a valid sampling procedure. To compare aphid populations when the different units of subsample are used, it is necessary to convert the data to a common unit. The standard unit for comparing aphid populations adopted in these experiments was the average or total number of aphids on 3 whole leaves per plant. The numbers of aphids found on leaflets 1, 4, and 7 were converted to the whole-leaf basis by dividing the total by 38.1 and multiplying by 100. This formula was derived from a previous study of aphid distribution on potato leaves.

Similar conversions for the numbers found on one-half of leaflets 1, 4, and 7 were made by using the divisor 19.05 instead of 38.1, since only one-half of each leaflet was observed. The position of the halves

of these leaflets was the same for all leaflets of a plant, but it was alternated from plant to plant.

SPECIAL PROCEDURES

Varieties of potatoes in experimental plots.—Potatoes of the Green Mountain variety were planted in all plots of experiments 1 and 2, while Katahdin was the variety used in experiments 3 and 4.

Plot size and experimental designs.—In experiments 1 and 4 the plots were 50 feet long, and in experiments 2 and 3 they were 89 feet long. All plots were 9 rows wide in experiments 1, 2, and 3 and they were 4 rows wide in experiment 4. All rows were 34 or 36 inches apart. The potato seed pieces in all plots were planted 1 foot apart.

The experimental designs were a 6 by 6 Latin square in experiment 1, and a 4 by 4 Latin square in experiments 2 and 3. In experiment 4, a 6 by 6 Latin square was used in 1947, and a 7 by 6 randomized block in 1948.

Treatments.—The descriptions of treatments for the first 3 experiments are given in Tables 1, 2, and 3. In experiment 4 (Table 4) 6 fungicidal-spray mixtures containing DDT were applied in 1947, while in 1948 there were 7 similar treatments. Three pounds of yellow cuprous oxide per 100 gallons were used in preparing all mixtures tested in experiment 4.

For experiment 4, equal amounts of DDT in emulsion were used in 5 of the 6 spray mixtures in 1947 and in 6 of the 7 mixtures in 1948. The remaining treatment each year was a spray mixture containing DDT in suspension, made with a 50 percent DDT wettable powder.

All emulsible concentrates in experiment 4 were essentially alike except for the solvent (Table 4). Except for treatment 5 in 1947, each contained, by weight, 25 percent of DDT, 73 percent of solvent and 2 percent of emulsifer. In treatment 5 in 1947, the concentrate contained 32 percent of DDT, 66 percent of solvent, and 2 percent of emulsifier. The emulsifying agent was an alkyl-phenoxy-polyethoxyethanol in all concentrates except treatment 2 in 1947, when an alkyl aryl polyether alcohol was substituted.

All emulsion sprays in experiment 4 contained 0.5 pound of DDT per 100 gallons, and the suspension spray contained 2 pounds of DDT per 100 gallons.

Dates of application of treatments and of aphid counts.—Spray mixtures in experiment 1 were applied as indicated in Figure 3. Those in experiments 2 and 3 were applied on the same dates, as shown in Figure 6. The application dates of treatments in experiment 4 are

TABLE 1

Treatments Applied in Experiment 1, 1946
(13 applications were made to all plots)

Treatment number	Amount in 100 gallons spray mixture		Pounds of DDT per acre	
	DDT	Fungicide	Per application	Total for season
1	None	Tribasic copper sulfate 5 lb.	0	0
2	Emulsion (0.5 lb. of DDT; 450 ml. of an alkylated naphthalene[1]; 22.5 ml. of an alkyl aryl polyether alcohol)	Bordeaux mixture (10-5-100)	0.625	8.13
3	Suspension (4 lb. of 50% wettable DDT powder)[2]	Tribasic copper sulfate 5 lb.	2.5[3]	31.25
4	None	Bordeaux mixture (10-5-100)	0	0
5	Suspension (4 lb. of 50% wettable DDT powder)[2]	Bordeaux mixture (10-5-100)	2.5[3]	31.25
6	Emulsion (0.5 lb. of DDT; 450 ml. of an alkylated naphthalene[1]; 22.5 ml. of an alkyl aryl polyether alcohol)	Tribasic copper sulfate 5 lb.	0.625	8.13

[1] Initial boiling point 460° F.; final boiling point 560° F.
[2] In the first application only 2 pounds of the 50% wettable powder were used in each 100 gallons of spray mixture.
[3] 1.25 pounds of DDT in the first application (July 3).

TABLE 2

Treatments Applied in Experiment 2, 1946
(10 applications to all plots)

Treatment number	Amount in 100 gallons spray mixture		Pounds of DDT applied per acre	
	DDT	Fungicide	Per application	Total for season
1	1.5 lb. of 50% wettable powder	Bordeaux mixture (10-5-100)	0.94	9.4
2	1.5 lb. of 50% wettable powder	Tribasic copper sulfate 5 lb.	0.94	9.4
3	1.5 lb. of 50% wettable powder	2 qts. disodium ethylene bisdithiocarbamate, 1 lb. zinc sulfate, ½ lb. lime (nabam)	0.94	9.4
4	1.5 lb. of 50% wettable powder and 40 ml. of decylbenzene sodium sulfonate	Bordeaux mixture (10-5-100)	0.94	9.4

TABLE 3

Treatments Applied in Experiment 3, 1946
(10 applications were made to all plots)

Treatment number	Amount in 100 gallons spray mixture		Pounds of DDT per acre	
	DDT	Fungicide	Per application	Total for season
1	0.5 lb. of DDT in 450 ml. of an alkylated naphthalene[1] with 22.5 ml. of an alkyl aryl polyether alcohol[2]	2 qts. of disodium ethylene bisdithiocarbamate, 1 lb. of zinc sulfate, ½ lb. of lime (nabam)	0.625	6.25
2	0.5 lb. of DDT in 450 ml. of an alkylated naphthalene[1] with 126.2 ml. of an alkyl aryl polyether alcohol	Tribasic copper sulfate 5 lb.	0.625	6.25
3	0.5 lb. of DDT in 450 ml. of an alkylated naphthalene[1] with 22.5 ml. of an alkyl aryl polyether alcohol[2]	Bordeaux mixture (10-5-100)	0.625	6.25
4	0.5 lb. of DDT in 450 ml. of an alkylated naphthalene[1] with 126.2 ml. of an alkyl aryl polyether alcohol	Bordeaux mixture (10-5-100)	0.625	6.25

[1] Initial boiling point 460° F.; final boiling point 560° F.
[2] Treatments 1 and 3 contained the ordinary concentration of emulsifying agent in emulsible concentrates of DDT.

shown in Figures 9 and 10. The dates of aphid counts are shown in tables A, B, C, D, and E of the appendix.

Tuber yield.—The yield of tubers after the plants had been killed by frost was determined by digging the 3 middle rows of all plots in experiments 1, 2, and 3 and the 2 middle rows of the plots in experiment 4. All the tubers from several plants on each end of these rows were first dug by hand and discarded. The plants remaining in the sample rows were then lifted by a mechanical digger and all tubers were picked up and weighed. In experiment 1 the tubers were then graded, and weights by grades were obtained. In experiment 4 the number of tubers in each grade was also determined.

Leafroll spread.—The amount of leafroll spread during an experiment was determined by subtracting the percent of leafroll in the seed potatoes used in planting the plots from that in the plots at the end of the season. The former was obtained by either examining the plants in the plots for chronic symptoms of leafroll early in the summer or by similar readings, the preceding winter, of plants grown in Florida from samples of seed potatoes taken from the supply of seed used in planting the plots. Leafroll incidence at the close of the season was deter-

TABLE 4

Treatments Applied in Experiment 4, 1947 and 1948
(12 applications of each treatment in 1947 and 13 in 1948 were made to all plots)

Treatment number	Solvent for emulsible concentrate[1] used in preparing DDT emulsions			Pounds of DDT applied per acre	
	Solvent	Petroleum fraction		Per application	Total for season
		Initial boiling point (°F.)	Final boiling point (°F.)		
	1947				
1	Aromatic solvent No. 3	387	485	0.6	7.2
2	Xylene	278.6	284	0.6	7.2
3	Alkylated naphthalene No. 1	420	485	0.6	7.2
4	70% aromatic solvent No. 1	360	560	0.6	7.2
5	Alkylated naphthalene No. 2	460	530	0.6	7.2
6	None (wettable powder)	—	—	2.4	28.8
	1948				
1	None (wettable powder)	—	—	2.4	31.2
2	70% aromatic solvent No. 1	360	560	0.6	7.8
3	Xylene	278.6	284	0.6	7.8
4	Aromatic solvent No. 2	392	530	0.6	7.8
5	Aromatic solvent No. 3	387	485	0.6	7.8
6	Alkylated naphthalene No. 1	420	485	0.6	7.8
7	Alkylated naphthalene No. 2	460	530	0.6	7.8

[1] The emulsible concentrates for treatments 1, 3, 4, and 5 in 1947 and for treatments 2, 3, 4, 5, 6, and 7 in 1948 were supplied by Eastern States Farmers' Exchange, West Springfield, Massachusetts.

mined by growing in Florida during the winter samples of tubers taken from the plots for that purpose.

Leafroll determinations at the end of the season were limited to experiments 1, 2, and 3. In experiments 2 and 3, just prior to harvest, 1 tuber was taken from every plant in the 2 middle rows of each plot, excluding 6 hills on each end of the rows. In experiment 1, tuber samples for leafroll determination were taken from the plots at intervals during the latter part of the season so as to determine the rate and time of leafroll spread. Five samplings of tubers were made, on each of the following dates: August 8-9, 17, 27, and September 6 and 29. These dates were selected on the basis of data being obtained concurrently in connection with studies of aphid flight. The first sampling was made by taking 1 tuber from every fourth plant in rows 2, 3, 7, and 8 in all plots, excluding 3 plants on each end of these rows. For the three subsequent samplings, tubers were taken in like manner from plants just beyond those used at the preceding time of sampling. In this way when the fourth sampling had been completed the entire plant population in 4 of the 9 rows in a plot had contributed a tuber to a sample. The fifth sample was obtained just before harvest by removing a tuber from

every third plant in the 3 middle rows of each plot, excluding 3 plants on each end of these rows.

DISCUSSION OF RESULTS

EXPERIMENT 1. EFFECTS OF DDT WITH CERTAIN FUNGICIDES IN 1946

Plant appearance.—Observations made at intervals throughout the season failed to show any visible injury to the potato foliage from any of the treatments applied to the plots in this experiment. After a light frost in mid-September, the damage to individual plants was less severe in plots treated with tribasic copper sulfate than in those treated with Bordeaux mixture.

Early in August differences in plant appearance due to aphid feeding began to show up, and these became more pronounced as the season progressed. In plots to which DDT was being applied, the plants remained healthy and vigorous. In plots to which no DDT was being applied, the plants soon began to show the typical symptoms of aphid damage. Among the symptoms of aphid damage are included the presence of honeydew on the upper surfaces of leaves, the downward curling or cupping of the leaves, and the dying of foliage beginning at the bottom of the plant.

Figure 2A is a general view, early in September, of a plot to which Bordeaux mixture, without DDT, was applied at weekly intervals throughout the season. In this view the lack of lower leaves is seen on the plants in the foreground. Figure 2B shows the typical appearance of individual plants shown in Figure 2A. These plants show some of the symptoms of aphid damage mentioned above and, in addition, illustrate advanced symptoms of aphid damage by the presence of dead stalks. In contrast with Figures 2A and 2B, the plants shown in Figure 2C had been protected from aphids by spraying weekly throughout the season with a mixture containing DDT in emulsion and Bordeaux. All of the foliage is still present on the plants shown in Figure 2C, including the large bottom leaves which overhang, lie close to and hide the high-hilled ridge in which the potato plants are growing. All 3 photographs were taken on the same day.

Aphid populations.—Figures 3 to 5, inclusive, show by treatments the population trends of 3 species of aphids in experiment 1. The figures show the average numbers of aphids per plot on a uniform basis throughout the season. The average numbers of aphids per plot, on the basis of the actual number and size of subsample units employed in each count, are shown in the Appendix, Table A. It will be seen that large populations of the buckthorn aphid developed in plots not treated with DDT,

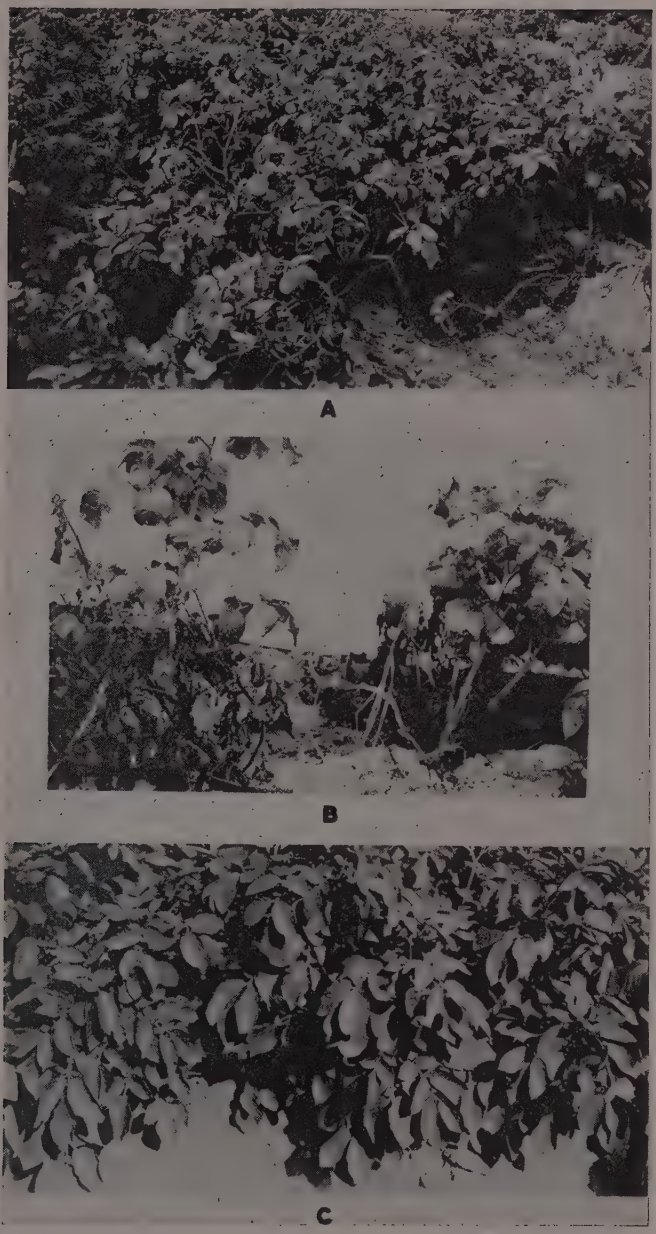


FIGURE 2.—Green Mountain plants in Experiment 1 on September 7, 1946. In each case Bordeaux mixture was used but in the upper view no DDT had been applied, whereas in the lower view a DDT emulsion was applied in the spray mixture throughout the season. The middle view is a close-up of some of the plants in the upper view.

but that populations of the potato and green peach aphids were relatively small even at their peaks.

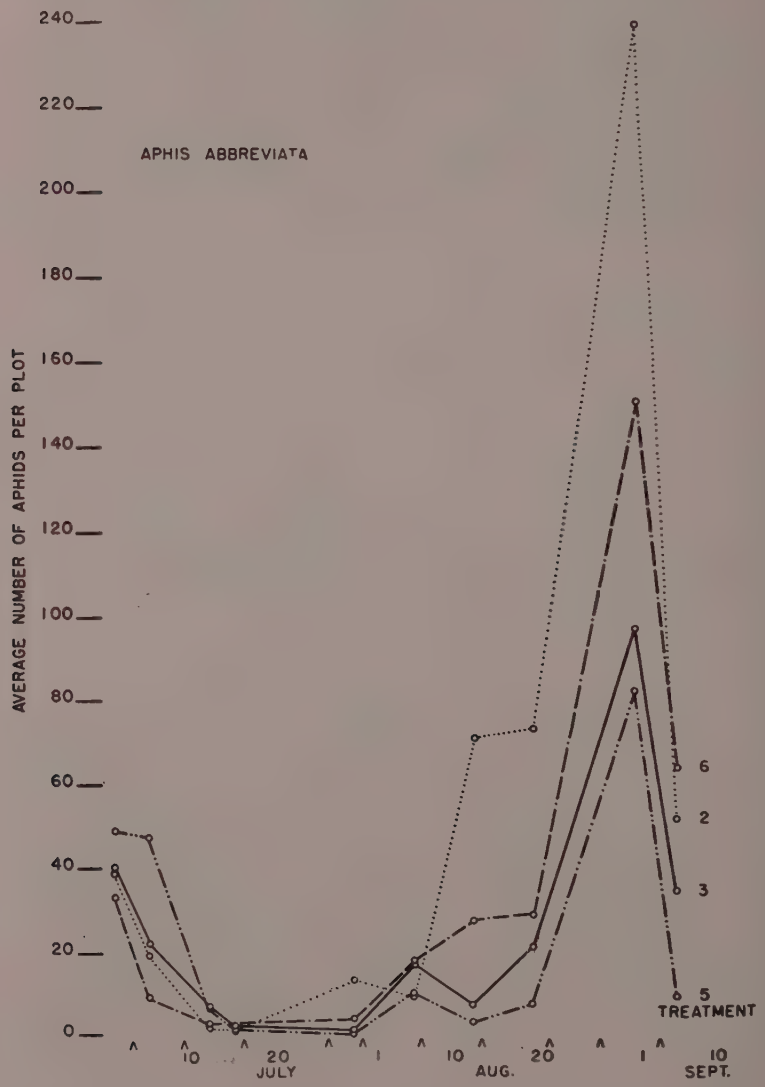
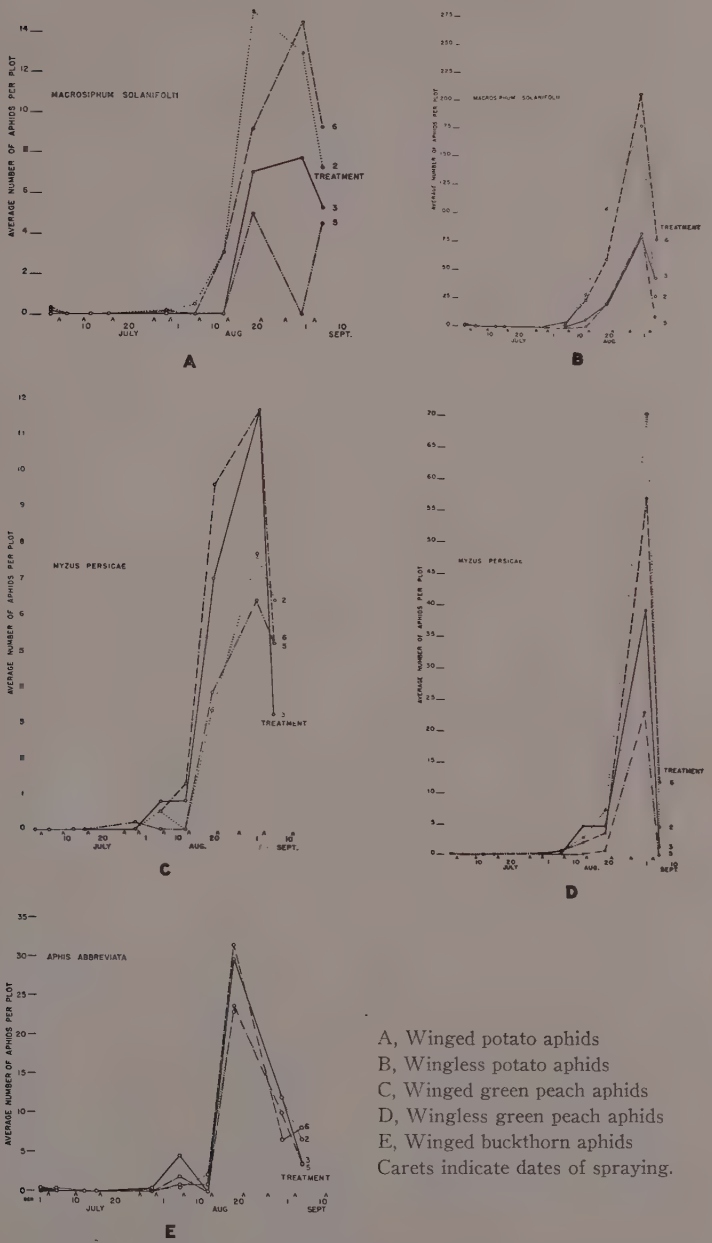


FIGURE 3.—Average number of wingless buckthorn aphids on 25 plants per plot on the basis of 3 whole leaves per plant for plants receiving DDT and a fungicide (from Table A of the Appendix). Carets indicate dates of spraying.



A, Winged potato aphids
B, Wingless potato aphids
C, Winged green peach aphids
D, Wingless green peach aphids
E, Winged buckthorn aphids
Carets indicate dates of spraying.

FIGURE 4.—Average numbers of aphids on 25 plants per plot on the basis of 3 whole leaves per plant for plants receiving DDT and a fungicide (From Table A of the Appendix).

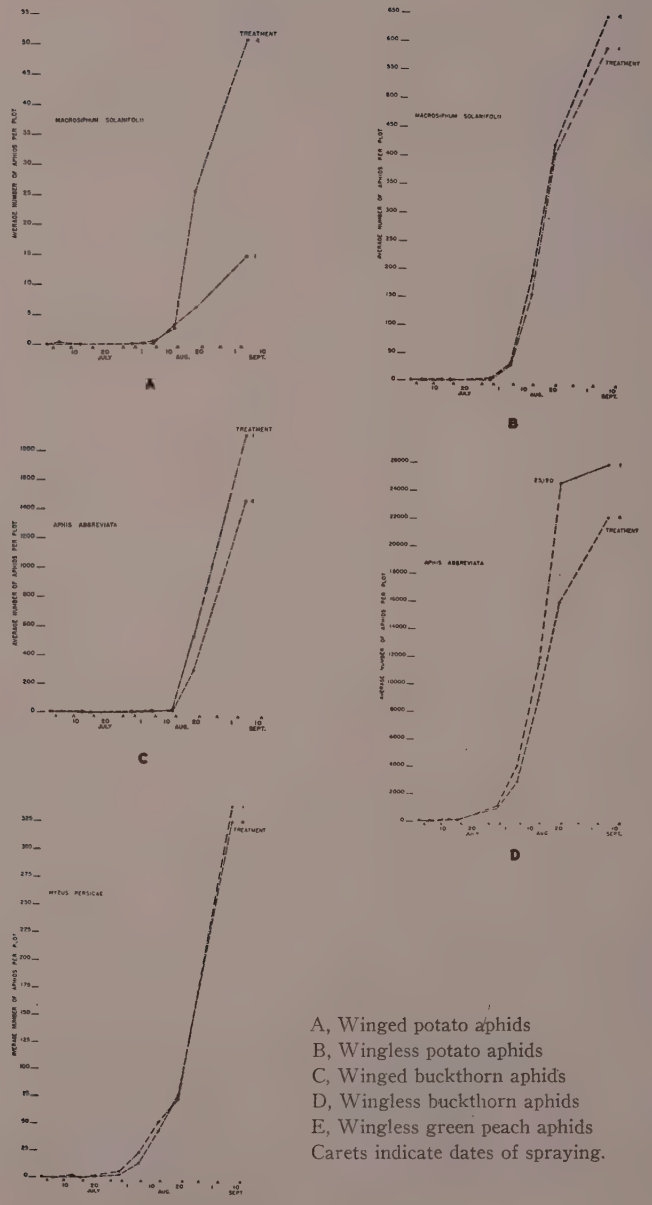


FIGURE 5.—Average number of aphids on 25 plants per plot on the basis of 3 whole leaves per plant for plants receiving a fungicide only (From Table A of the Appendix).

The fungicide had an effect upon the size of the population of the buckthorn aphid that developed. No similar effect was found for the green peach and potato aphids, probably because of their small populations. Larger populations of the buckthorn aphid developed on plants treated with tribasic copper sulfate than on those treated with Bordeaux mixture. Previous experience has indicated that the fungicide used may influence aphid population trends on potatoes.

There were some differences in aphicidal value among the DDT-fungicide treatments which could have been due, in part, to the effect of the fungicide. After mid-August, the DDT emulsion was, or tended to be statistically, inferior to the wettable-powder preparations against the buckthorn aphid. The emulsion in Bordeaux mixture tended to be or was statistically inferior to the emulsion in tribasic copper sulfate against this aphid, except on September 5, when the counts showed an opposite tendency. There were no real differences between treatments containing the DDT wettable powder, regardless of the fungicide used. There were no differences due to treatments for winged buckthorn aphids at any time during the season.

Differences in populations of the potato aphid were restricted to the period from August 12 to September 5. Again, the treatments containing the emulsion tended to be or were statistically inferior to those containing the wettable powder. While DDT emulsion in Bordeaux mixture was inferior on August 12 and 19, DDT emulsion in tribasic copper sulfate spray was inferior on August 31 and September 5. There were no real differences between the treatments containing the DDT wettable powder when applied with either of the fungicides.

The only difference of importance for winged potato aphids was found on August 31, when the DDT emulsion in tribasic copper sulfate spray was inferior to the other treatments. The DDT emulsion in Bordeaux mixture was inferior to wettable powder in Bordeaux mixture but not to wettable powder in tribasic copper sulfate spray.

At no time during the season were there differences due to treatment in populations of the green peach aphid.

Tuber Yield.—The yield of tubers as shown in Table 5 was increased by all the DDT treatments. The DDT emulsion in Bordeaux mixture caused the smallest increase. There was no significant difference in the increases in yield among the other three DDT treatments.

The effects of the treatments upon yields agree in only a very general way with their effects upon aphid populations. It is believed that a large part of any lack of correlation for those treatments containing DDT can be attributed to differences in the depressing effect of the

fungicides upon yields. It is known, for example, from other work in many localities that Bordeaux mixture may depress yield.

Only relatively small numbers of aphids developed in plots treated with DDT. From other work it seems likely that there were too few aphids to influence yields to any extent, even though statistically there were significant differences in aphid populations in several instances.

TABLE 5

Average Yield of Potatoes in Experiment 1, 1946

Treatment[1]	Pounds per plot[2]	Bushels per acre
Tribasic copper sulfate	161.2	312.0
DDT emulsion in Bordeaux mixture	208.1	403.2
DDT wettable powder in tribasic copper sulfate	224.4	434.6
Bordeaux mixture	169.8	328.8
DDT wettable powder in Bordeaux mixture	229.8	445.0
DDT emulsion in tribasic copper sulfate	233.5	452.0
Difference required for significance (P = 0.05)	17.3	33.5

[1] See Table 1 for full description of treatments.
[2] 132 feet of row.

These results should not be interpreted to mean that, for practical purposes, the differences found between the different combinations of DDT with the two fungicides tested in this experiment are of no commercial importance. These differences may be important to growers who use machinery providing less effective plant coverage than that provided by the Slosser sprayer.

Leafroll spread.—Table 6 shows the percentage of leafroll spread at intervals during the latter part of the season.[9] These data indicate the percentage of plants in which leafroll had penetrated to the tubers by the time the sample was obtained. Since some time is required for the translocation of the leafroll virus from leaves to tubers, only the final set of figures is actually indicative of leafroll spread in the tops. The plants on which they are based lived until frost.

The seasonal spread of this virus disease was not sufficiently great for differences due to treatment to be detected. It is obvious from Table 6, however, that most of the spread occurred late in the season. This is the normal situation in years when leafroll does not spread excessively. It is probably correlated with the seasonal development of the green peach aphid, the important vector of leafroll.

[9] In Maine 1.05 percent of the plants growing from the seed planted in the spring in all plots had symptoms of chronic leafroll.

EXPERIMENT 2. INFLUENCE OF 3 FUNGICIDES UPON THE EFFECTIVENESS OF DDT WETTABLE POWDER IN 1946

Plant appearance.—There was no visible evidence of injury to the plants from any of the treatments. The plants in all plots appeared normal throughout the season.

Aphid populations.—Figures 6 and 7, as well as Table B of the Appendix, show by treatment the population trends of three species of aphids in this experiment. Aphid populations were not large at any time during the season, but they were considerably larger than those found in the DDT-treated plots of Experiment 1. This difference is attributed largely to the reduced amount of DDT applied in this experiment. The buckthorn aphid was the predominant species, followed by the potato and green peach aphids.

TABLE 6

Percent of Leafroll Spread into Tubers Prior to Different Dates in Experiment 1, 1946

Treatment[1]	August 8 and 9	August 17	August 27	September 6	September 29
Tribasic copper sulfate	1.3	1.3	0	.4	2.8
DDT emulsion in Bordeaux mixture	.4	2.8	0	.4	2.7
DDT wettable powder in tribasic copper sulfate	3.4	.5	0	1.5	5.5
Bordeaux mixture	0	.8	1.2	.4	2.0
DDT wettable powder in Bordeaux mixture	1.6	.8	1.7	.4	6.7
DDT emulsion in tribasic copper sulfate	1.6	1.3	.4	2.5	7.0

[1] See Table 1 for full description of treatments.

There were no significant differences among treatments until after July 29. All significant differences during the remainder of the season were confined to the buckthorn aphid, probably because the other 2 species were not present in large enough numbers. There was a tendency for larger populations of the buckthorn aphid to develop on plants treated with a mixture containing DDT in tribasic copper sulfate than on those treated with Bordeaux mixture containing DDT. Still larger populations of this aphid were found on plants treated with a mixture of nabam and DDT. The use of 0.94 pound of DDT per acre per application gave fairly good, but not commercially satisfactory, control of the aphids. The greater effectiveness of DDT in Bordeaux mixture was probably due in part to a fundamental influence of the fungicide upon the aphid population. From the results of this experiment, the advisability of including a spreading agent in a mixture of DDT (as a wettable powder) and Bordeaux mixture is open to question.

Tuber yield.—Table 7 shows the average yield by treatments. Although not statistically significant, there was a tendency for the nabam-

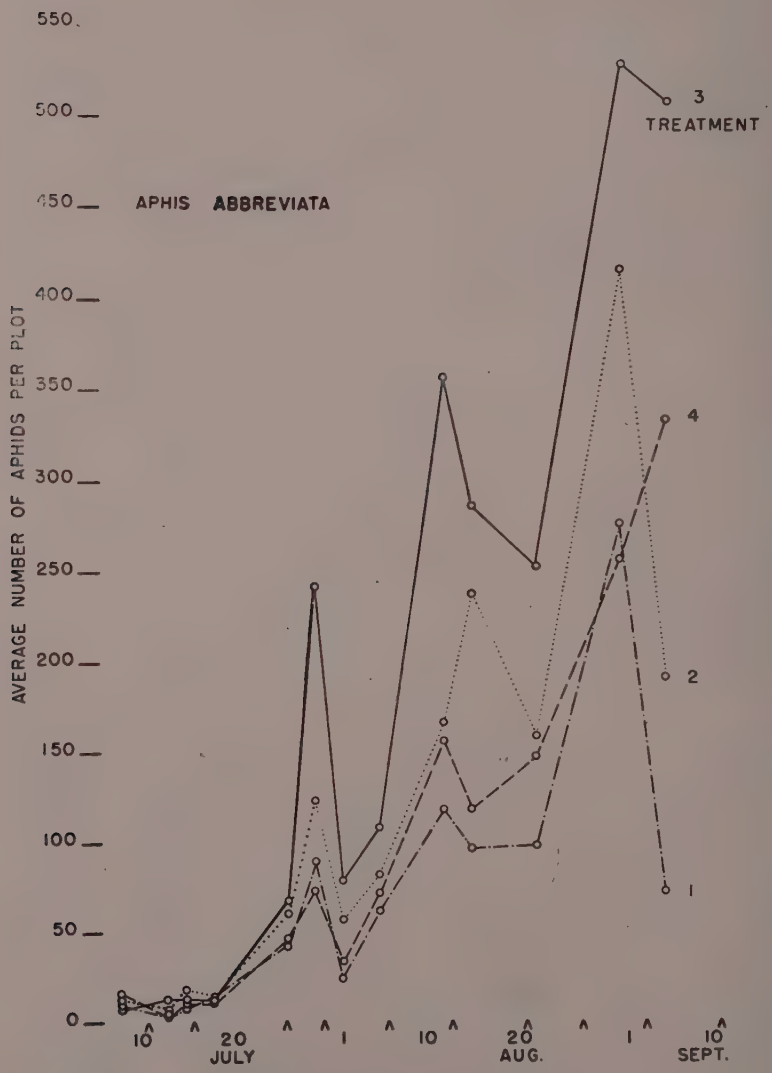


FIGURE 6.—Average number of wingless buckthorn aphids on 25 plants per plot on the basis of 3 whole leaves per plant for plants receiving DDT and a fungicide (From Table B of the Appendix). Carets indicate dates of spraying.

DDT mixture to give the largest yield. It appears that any differences in yield that might have resulted from differences in degree of aphid control were obscured by differences in the yield-influencing effects of the several fungicides used in the experiment.

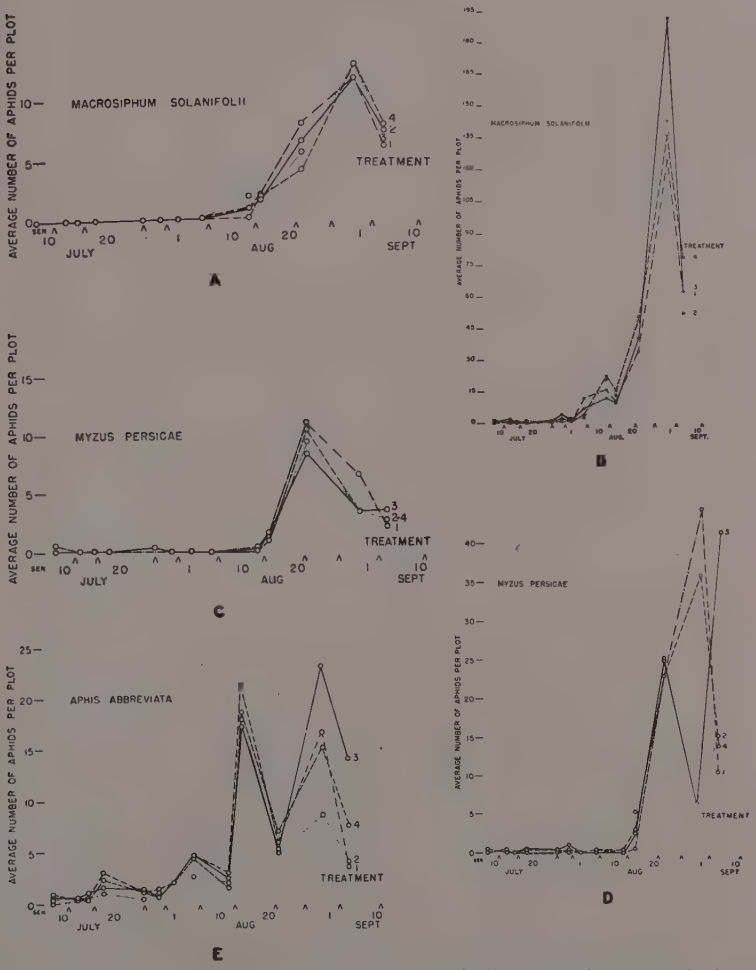


FIGURE 7.—Average number of aphids on 25 plants per plot on the basis of 3 whole leaves per plant for plants receiving DDT and a fungicide (from Table B of the Appendix). A, Winged potato aphids; B, Wingless potato aphids; C, Winged green peach aphids; D, Wingless green peach aphids; E, Winged buckthorn aphids. Carets indicate dates of spraying.

Leafroll Spread.—Table 7 shows leafroll readings of plants grown in Florida from tuber samples taken at harvest from each plot in this experiment. Field readings made during the summer of 1946 indicated that about 5 percent of the plants showed chronic symptoms of leafroll. This amount is included in the percentages shown in Table 7. Spread of the leafroll virus during the season was too small to justify any conclusions concerning the relative effectiveness of the treatments in this respect.

TABLE 7

Leafroll and Yield in Experiment 2, 1946

Treatment[1]	Number of plants		Percent leafroll	Average yield	
	Growing	Having leafroll		Pounds per plot[2]	Bushels per acre
DDT in Bordeaux mixture	327	21	6.4	326	481
DDT in tribasic copper sulfate	310	40	12.9	329	485
DDT in nabam	258	33	12.8	344	507
DDT in Bordeaux mixture + wetter-spreader	306	37	12.1	337	496

[1] See Table 2 for description of treatments.
[2] 232 feet of row.

EXPERIMENT 3. EFFECTS OF THE AMOUNT OF EMULSIFYING AGENT UPON THE INSECTICIDAL VALUE OF DDT EMULSIONS WHEN APPLIED WITH THREE FUNGICIDES IN 1946

Plant appearance.—No visible treatment injury to the foliage in any of the plots was observed at any time during the season. It is of interest that, after a light frost in September, foliage of individual plants treated with nabam was less severely injured than that of plants treated with either Bordeaux mixture or tribasic copper sulfate.

Aphid populations.—Figure 8 and Table C of the Appendix show by treatment and by species the average number of aphids per plot found at intervals throughout the season in the plots in Experiment 3. The data in Table C of the Appendix show that no significant differences in degree of aphid control appeared before August 15 and that at no time during the season were differences due to treatments significant for the potato aphid.

One important difference between this and the preceding experiments was that the green peach aphid was relatively more abundant in these plots, whereas the other 2 species were somewhat less abundant. The Katahdin variety of potato is known to be a much more favorable host for the green peach aphid than is the Green Mountain variety.

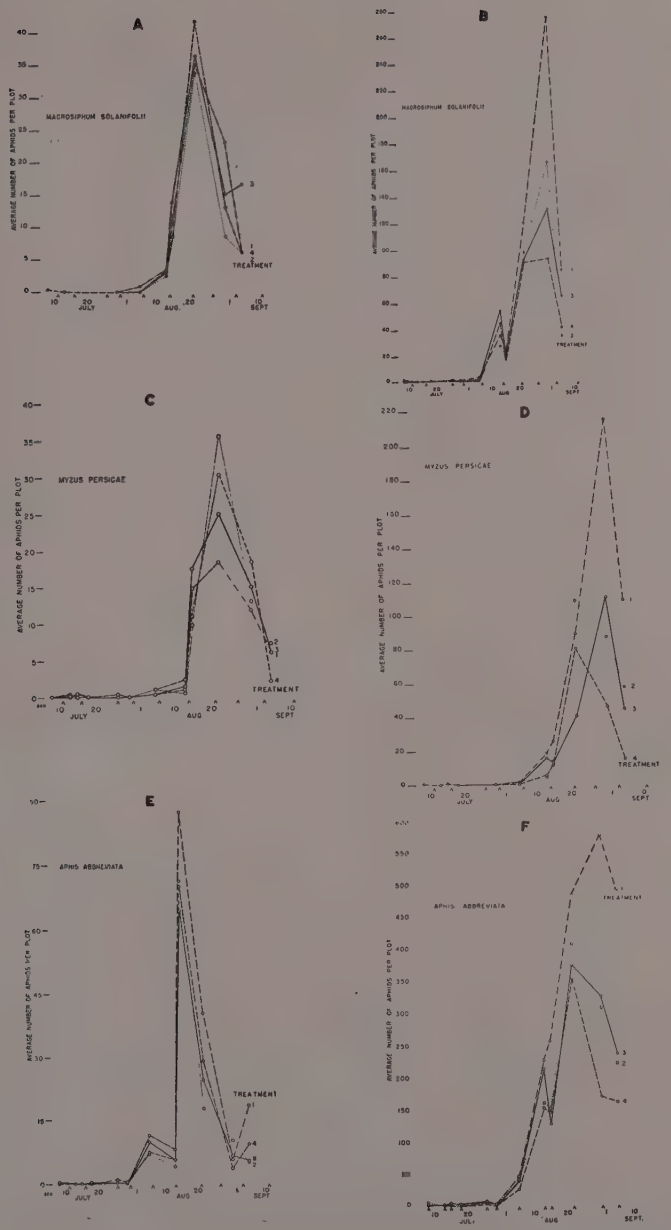


FIGURE 8.—Average number of aphids on 25 plants per plot on the basis of 3 whole leaves per plant for plants receiving DDT and a fungicide (from Table C of the Appendix). A, Winged potato aphids; B, Wingless potato aphids; C, Winged green peach aphids; D, Wingless green peach aphids; E, Winged buckthorn aphids; F, Wingless buckthorn aphids. Carets indicate dates of spraying.

Several factors may have affected aphid control in addition to the concentration of the emulsifier. Some of these were mentioned in connection with Experiment 2. The experimental design used in this experiment did not permit a valid comparison of the concentrations of the emulsifier, except in the Bordeaux mixture treatments. However, the results indicate that better control of wingless aphids may be expected from adding more of the emulsifying agent than is now being used in the preparation of emulsible concentrates of DDT. On the other hand, the use of additional emulsifier tended to reduce the toxicity or possibly the residual toxicity of the DDT to winged green peach aphids.

Tuber yield.—Table 8 shows the average yield by treatment for Experiment 3. An analysis of these data showed no significant differences between treatments. Here again, any variation in yield that may have resulted from possible differences in the insecticidal properties of the several mixtures was obscured by the effects of the fungicides. It is of interest that, as in Experiment 2, although it was not numerically significant, the largest yield of tubers was found in those plots where nabam was used.

Leafroll spread.—Field readings of the plants in the plots during the season showed that slightly less than 1 percent of the plants had symptoms of chronic leafroll. Tuber samples from the plots in this experiment were taken at harvest and later planted in Florida. The readings obtained are shown in Table 8, and they include the plants having chronic leafroll at the end of the preceding season. As in Experiments 1 and 2, the seasonal spread of leafroll was too small to permit conclusions as to the effect of the several treatments upon the spread of this virus disease. There was a tendency toward a greater spread of leafroll in the plots treated with nabam than in those treated with the other fungicides. This result is often associated with longer life of and higher yields from the plants.

EXPERIMENT 4. EFFECTS OF DIFFERENT SOLVENTS USED IN MAKING DDT EMULSIBLE CONCENTRATES ON THE INSECTICIDAL VALUE OF DDT EMULSION WHEN APPLIED IN A MIXTURE CONTAINING YELLOW CUPROUS OXIDE IN 1947 AND 1948

Plant appearance.—Observations failed to show any real differences between treatments at any time during either season in the general appearance of the plants in the plots.

Although no injurious effects of treatments to the foliage were observed, there were noticeable differences in 1948 between treatments

TABLE 8

Leafroll and Yield in Experiment 3, 1946

Treatment[1]	Number of plants		Percent leafroll	Average yield	
	Growing	Having leafroll		Pounds per plot[2]	Bushels per acre
DDT in nabam + usual amount of emulsifier	297	17	5.7	304	448
DDT in tribasic copper sulfate + more emulsifier	299	5	1.7	294	433
DDT in Bordeaux mixture + usual amount of emulsifier	293	11	3.8	280	413
DDT in Bordeaux mixture + more emulsifier	276	9	3.3	280	413

Differences not significant by the F test for P=0.05.
[1] See Table 3 for full description of treatments.
[2] 232 feet of row.

in the time when the potato plants began to flower and in the duration of the flowering period (Table 9). These data show that plants treated with DDT emulsion containing xylene began to flower earlier than plants receiving the other treatments. A later count (Table 9) showed that there were also important treatment differences in the length of the flowering period. Plants treated with emulsions containing the aromatic solvents with the intermediate and the high initial boiling points tended to approach the end of their flowering period sooner than those receiving any of the other treatments. Plants treated with the DDT wettable powder remained in flower later than plants receiving any of the DDT emulsions.

Aphid populations.—Aphid populations by treatments are shown in Tables D and E (Appendix), and in Figures 9 to 11, inclusive.

The fields chosen for these experiments were located fairly near a thicket of alder-leaved buckthorn,[10] the principal overwintering host of the buckthorn aphid in northeastern Maine. The buckthorn aphid was the dominant species, followed by the potato aphid. Green peach aphids were not numerous at any time, but they were more generally present in August than earlier in the year. Foxglove aphids were not abundant either year. In 1948 they were most numerous during the early part of the season.

While there were no untreated plots in this experiment, aphid populations in untreated plots in other locations on the farm developed to high levels. Thus the low aphid populations found here indicate that all treatments resulted in good commercial control of the aphids.

Analysis of the data on which Tables D and E (Appendix) are based showed very few significant differences among treatments. The

[10] *Rhamnus alnifolia* L'Her.

relative standings of treatments in respect to percentage of plants populated by each species of aphid were, in general, similar to those shown for aphid populations.

During the early part of the season DDT in the emulsions gave better control of the buckthorn and potato aphids than did DDT when

TABLE 9

Average Number of Flower Clusters per Plot on Katahdin Potatoes, Experiment 4, 1948

Solvent for DDT emulsible concentrate[1]	July 16	August 17
None (wettable powder)	14.8	102.0
Aromatic solvent No. 1	16.8	64.0
Xylene	28.4	65.0
Aromatic solvent No. 2	18.4	43.6
Aromatic solvent No. 3	13.4	36.2
Alkylated naphthalene No. 1	18.6	72.0
Alkylated naphthalene No. 2	14.8	51.6
Difference required for significance (P = 0.05)	8.2	30.2

[1] See Table 4 for full description of treatments.

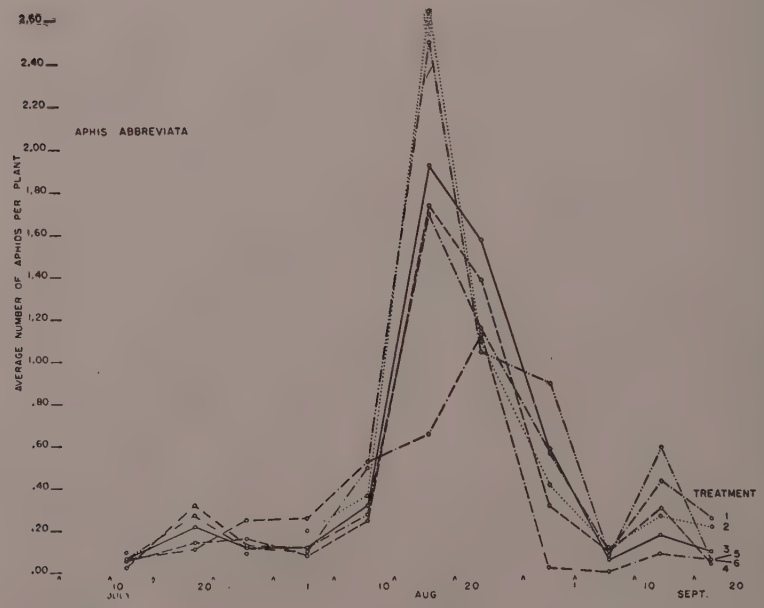


FIGURE 9.—Average number of wingless buckthorn aphids per plant on the basis of 3 whole leaves per plant, 25 plants per plot, for plants receiving DDT and a fungicide (from Table D of the Appendix). Carets show dates of spraying.

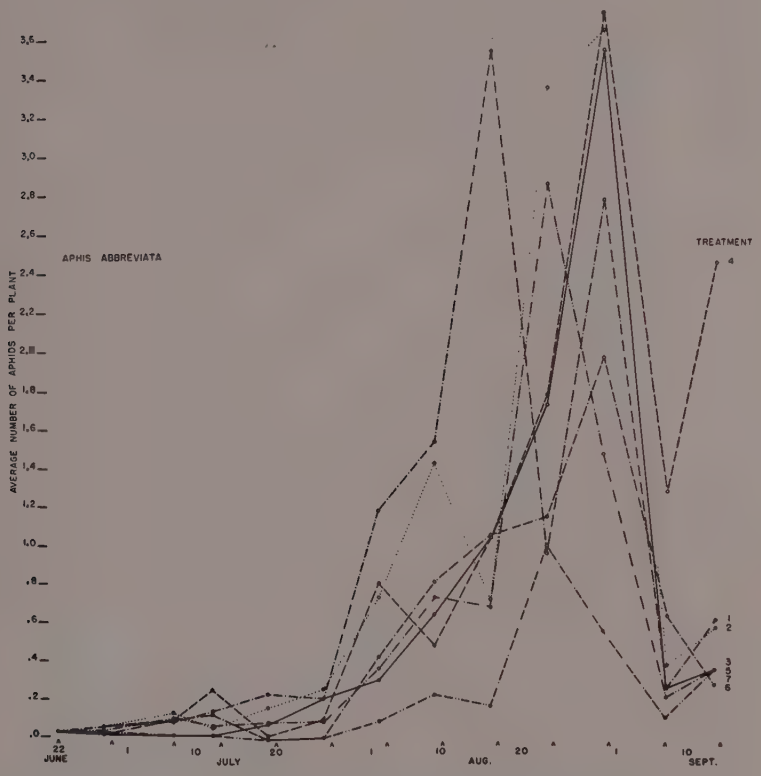


FIGURE 10.—Average number of wingless buckthorn aphids per plant on the basis of 3 whole leaves per plant, 25 plants per plot, for plants receiving DDT and a fungicide (from Table E of the Appendix). Carets indicate dates of spraying.

applied as a wettable powder, at a rate of about 4 times that in the emulsions. As more material was applied, the situation began to change, and sometime between the middle and the end of August the wettable powder began to give relatively better aphid control. However, populations on all plots were low.

From the standpoint of aphid control only, and, regardless of other considerations, there were no outstanding differences among any of the several solvents tested. In this connection it should be mentioned that green peach and foxglove aphids were not present in the plots in sufficient numbers to permit any conclusions regarding effects of treatments on those species.

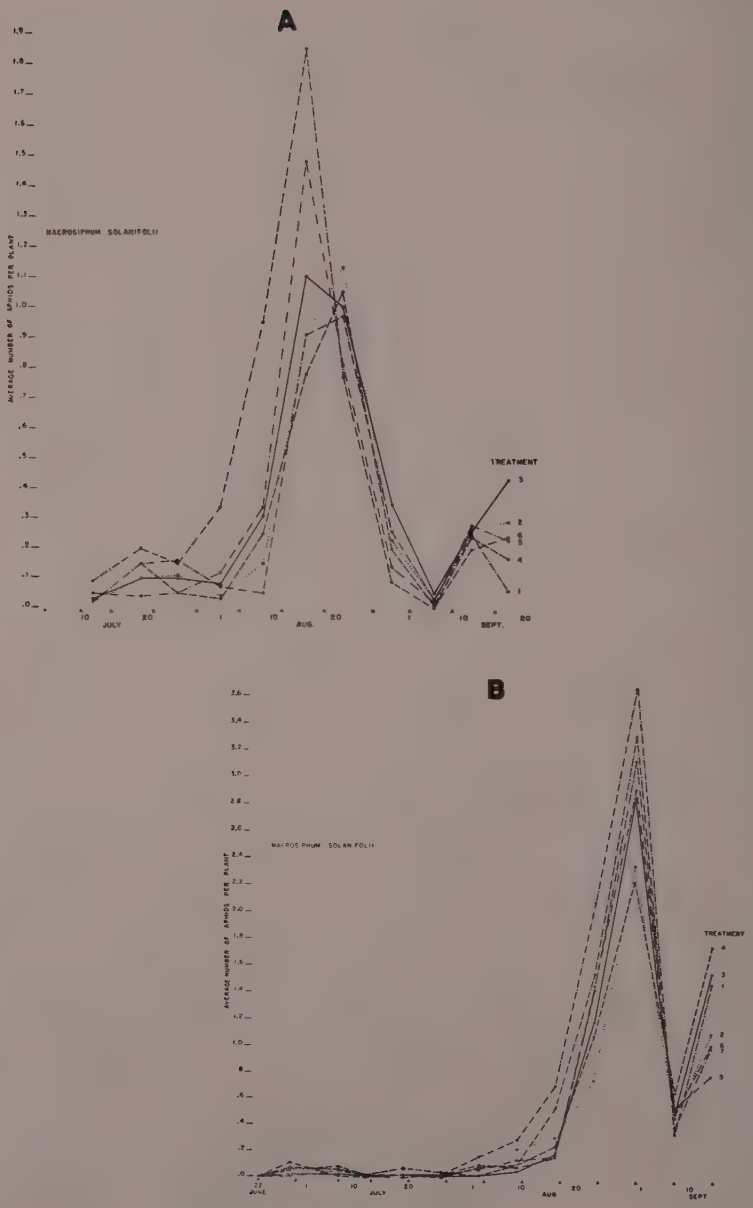


FIGURE 11.—Average number of wingless potato aphids per plant on the basis of 3 whole leaves per plant, 25 plants per plot, for plants receiving DDT and a fungicide (from Tables D and E of the Appendix). A, 1947; B, 1948.

There were several differences of potential importance from time to time between treatments for the buckthorn and potato aphids, but they varied considerably between seasons and at various times during the season.

Tuber yields.—The average total yields of tubers by treatments are shown for 1947 and 1948 in Table 10. There were no real differences between treatments in 1947 or 1948.

The tubers from each plot were graded, reweighed, and counted. Except for tubers 1½ to 1⅞ inches in diameter from the test in 1948, no real differences between treatments were found when the data thus obtained were analyzed. Table 10 shows, by treatments, the average numbers and weights per plot of the tubers 1½ to 1⅞ inches in diameter in 1948. The largest weights of tubers of this size were obtained from plots treated with an emulsion containing xylene, a suspension containing wettable powder, and an emulsion containing the alkylated naphthalene having the higher initial boiling point. The weight of tubers of this size from plots treated with an emulsion containing the aromatic solvent having the lowest initial boiling point was larger than that from plots treated either with an emulsion containing the alkylated naphthalene having the lower initial boiling point or with the aromatic solvents having the intermediate and highest initial boiling points. The latter treatment was almost inferior to the emulsion containing the alkylated naphthalene having the lower initial boiling point.

Differences between treatments in average numbers of the smaller size tubers (Table 10) were rather similar to those indicated for weights.

Although there were no differences of significance between treatments in total yield of tubers there were some real differences in the number and weight of tubers 1½ to 1⅞ inches in diameter. This indicates there may have been some differences between treatments in the relative depressing effect upon yield exerted by the several solvents. Rainfall was deficient during July, August, and September in 1948.[11] Had the precipitation been normal, the smaller tubers might have attained the size of U.S. No. 1. With such marked differences in the numbers of tubers 1½ to 1⅞ inches in diameter (Table 10), should many of them have become large enough to make the better grade, real differences between treatments from a commercial standpoint could have resulted.

[11] Rainfall during July was 2.32 inches, August 2.70 inches, and September 2.59 inches. The normal amounts for these months are 4.04 inches, 3.28 inches, and 3.65 inches, respectively.

TABLE 10

Average Yield of Potatoes in Experiment 4, 1947 and 1948

Solvent for DDT emulsible concentrate[1]	All potatoes in 1947		All potatoes in 1948		Potatoes 1½ to 1⅞ inches in diameter in 1948	
	Pounds per plot[2]	Bushels per acre	Pounds per plot[2]	Bushels per acre	Pounds per plot[2]	Number per plot[2]
None (wettable powder)	139	405	153	444	7.30	64.2
Aromatic solvent No. 1	137	399	155	452	6.56	58.6
Xylene	133	386	165	482	7.46	66.4
Aromatic solvent No. 2			165	479	5.20	46.6
Aromatic solvent No. 3	139	403	162	473	5.54	49.2
Alkylated naphthalene No. 1	134	390	159	463	5.80	52.6
Alkylated naphthalene No. 2	133	388	158	459	7.72	64.8
Difference required for significance (P = 0.05)	[3]	[3]	[3]	[3]	0.63	5.4

[1] See Table 4 for full description of treatments.
[2] 88 feet of row.
[3] Not significant by the F test.

SUMMARY

Three experiments to determine the insecticidal value of DDT when used with each of three fungicides in the control of aphids on potatoes were conducted during 1946. A fourth experiment concerned with the use of different solvents in making DDT emulsible concentrates was carried out in 1947 and 1948. All tests were made on small replicated plots of potatoes growing in the field. All treatments were spray mixtures applied by a power sprayer especially designed to provide more thorough plant coverage than is obtained with the use of conventional machinery. A uniform rate of 125 gallons of spray mixture per acre was applied in all instances at a pressure of from 100 to 120 pounds per square inch.

In Experiment 1 two fungicidal mixtures, with and without DDT, were applied weekly for a total of 13 applications. The fungicides were Bordeaux mixture (10-5-100) and tribasic copper sulfate (5-100). DDT, as a wettable powder and as an emulsible concentrate, was mixed with each fungicide, making a total of 6 treatments. The wettable powder and emulsible concentrate were added at rates of 2 pounds and 0.5 pound of technical DDT per 100 gallons of the fungicidal mixture, respectively.

None of the treatments had any apparent injurious effects upon the plants in any of the plots.

Plants treated with the mixture containing tribasic copper sulfate but no DDT were found to have much larger populations of wingless buckthorn aphids than plants treated with Bordeaux mixture only. The effect of the fungicide upon the aphid population trend tended to

obscure any possible differences in the insecticidal properties of those treatments containing DDT.

For aphid control during the early part of the season, DDT emulsions tended to be or were superior to DDT as a wettable powder, whereas during the latter part of the season the reverse was true. There were also variations depending on the particular fungicide used.

The yield of tubers was increased by all the DDT treatments. The DDT emulsion in Bordeaux mixture caused the smallest increase, owing to a depressing effect of Bordeaux mixture on plant growth. There was no significant difference in the increases in yield among the other three DDT treatments. That the treatment differences as expressed in yields agreed in only a general way with those for aphid control may have been due largely to differences in yield-depressing effects of the fungicides themselves.

The seasonal spread of leafroll was not sufficiently great to reveal any differences that might have been due to treatments.

Experiment 2 was designed to determine possible effects of the fungicide used on the insecticidal value of DDT when used as a wettable powder. A dosage of 0.75 pound of DDT per 100 gallons of spray mixture was applied weekly for a total of 10 applications. The fungicides used were Bordeaux mixture, tribasic copper sulfate, and nabam. A fourth treatment consisted of Bordeaux mixture containing the same amount of DDT, but with a wetting-spreading agent.

None of the treatments caused any visable injury to the growing plants.

A study of the aphid population trends showed no significant differences among treatments through July 29. Later, all differences were confined to the wingless forms of the buckthorn aphid. On and after August 1 the treatment containing DDT in nabam tended to be inferior to DDT in Bordeaux mixture. DDT in tribasic copper sulfate tended to be inferior to that in Bordeaux mixture but superior to that in nabam. Although not significant at any time during the season, the DDT-Bordeaux mixture containing a spreading agent tended to be inferior to a similar mixture not containing this agent. Any clear-cut influences of the fungicides upon the insecticidal properties of DDT were likely obscured by their direct effects upon the aphid populations developing on the plants. In general, as might be expected from the amount of DDT used, unsatisfactory commercial control of the aphids was obtained with all treatments.

There were no differences between treatments in tuber yield. The seasonal spread of leafroll was too small to justify conclusions con-

cerning the relative effectiveness of the several treatments in this connection.

Experiment 3 was designed to determine the effects of emulsions made with emulsible concentrates of DDT containing various amounts of the emulsifying agent when used in connection with any one of three fungicides. A uniform amount of DDT (0.5 pound) per 100 gallons of fungicidal spray mixture was applied weekly for a period of 10 weeks. In 2 of the preparations, the emulsifying agent comprised 4.76 percent of the total volume of solvent and emulsifier, while in the other 2 it comprised 21.9 percent. The fungicides were Bordeaux mixture, tribasic copper sulfate, and nabam.

There was no visible injury to the plants from any of the 4 treatments.

Better control of wingless aphids was obtained by adding more emulsifying agent to the emulsible concentrate than is ordinarily used, but such a mixture resulted in less residual toxicity for winged green peach aphids than was obtained from the use of emulsible concentrates containing a normal amount of emulsifying agent.

There were no differences between treatments in tuber yield.

The small amount of leafroll spread in all plots did not permit conclusions regarding possible effects of the various treatments on the transmission of this virus disease.

Experiment 4 was carried out to determine the effects of several different solvents used in making emulsible DDT concentrates on potato plants and on the insecticidal properties of such DDT when used with spray mixtures containing yellow cuprous oxide. Five solvents were compared in 1947, and 6 in 1948. Another spray mixture included both years contained DDT as a wettable powder.

All formulations tested resulted in satisfactory commercial control of the aphids, without visible injury to the plants. Although some differences between treatments were found in respect to control of the buckthorn, potato, and foxglove aphids, they were not of commercial importance. Neither were these differences consistent among the aphids, between years, or within a given season.

No differences were found between treatments in the total yield of tubers in 1947 or 1948. Some differences were found, however, in the weight and in the number of tubers 1½ to 1⅞ inches in diameter for that part of the experiment conducted in 1948. Although not of commercial importance, these differences may indicate that the solvent used in preparing emulsible concentrates of DDT for making emulsion sprays might, under very favorable conditions of growth, exert some influence upon the yield of tubers grading U.S. No. 1.

APPENDIX TABLE A

Average Numbers of Aphids per Composite Plot-Sample in Experiment 1, 1946

Treatment	On the basis of whole-leaf subsamples from 25 plants					On the basis of leaflet-subsamples				
						25 plants			10 plants	
	July 1	July 5	July 12	July 15	July 29	Aug. 5	Aug. 12	Aug. 19[1]	Aug. 31	Sept. 5[1]
Buckthorn aphid										
1. Tribasic copper sulfate only	40+T[2]	51+T	108	97	1186	1534+1	4412+7	9598+201	—	4273+288
2. DDT emulsion in Bordeaux mixture	39	19+T	2	1	13+T	3+T	27+1	28+9	37+2	8+1
3. DDT wettable powder in tribasic copper sulfate	40+T	22	7	2	1+T	6+2	3	8+11	15+2	5+1
4. Bordeaux mixture only	47+T	44+T	104+T	142	883+T	1118+1	3414+3	6120+113	—	3387+221
5. DDT wettable powder in Bordeaux mixture	49	47	6	1	0	4+1	1	3+9	13+2	1+1
6. DDT emulsion in tribasic copper sulfate	33+T	9	3	1	4	7+T	11+T	11+12	23+1	10+1
Difference required for significance (P = 0.05): All treatments	[3]	22.5	26.9	31.5	280.3	298 5	693.1	[3]	[3]	[3]
DDT treatments only	[3]	26.6	[3]	[3]	[3]	[3]	[3]	12.9	11.8	4.4
Fungicides only	[3]	[3]	[3]	[3]	[3]	[3]	[3]	2635.4	—	442.3
Green peach aphid										
1. Tribasic copper sulfate only	T	0	T	0	6+T	9	20	28+1	—	52
2. DDT emulsion in Bordeaux mixture	T	0	0	0	0	T+T	1	3+1	10+1	1+1
3. DDT wettable powder in tribasic copper sulfate	0	0	0	0	0	0+T	2+T	2+3	6+2	T+1
4. Bordeaux mixture only	T	0	2	0	3	5	17+T	29+1	—	48+1
5. DDT wettable powder in Bordeaux mixture	0	0	0	0	0+T	0	0	T+2	4+1	0+1
6. DDT emulsion in tribasic copper sulfate	T	0	0	0	0	T+T	1+1	1+4	9+2	2+1
Difference required for significance (P = 0.05)	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]
Potato aphid										
1. Tribasic copper sulfate only	2	1	1	T	3	12	61+1	155+2	—	90+2
2. DDT emulsion in Bordeaux mixture	1	1	0	0	0+T	1+T	11+1	39+6	27+2	4+2
3. DDT wettable powder in tribasic copper sulfate	2+T	1	0	0	0	1	3	8+3	12+1	7+1
4. Bordeaux mixture only	T	2+T	1	T	6	13+T	73+1	160+10	—	98+8
5. DDT wettable powder in Bordeaux mixture	2+T	1	0	0	0+T	0	1	8+2	13	2+1
6. DDT emulsion in tribasic copper sulfate	2	T	0	0	0	1	9+1	23+4	31+2	12+1
Difference required for significance (P = 0.05): All treatments	[3]	[3]	[3]	[3]	[3]	[3]	20.8	[3]	[3]	[3]
DDT treatments only	[3]	[3]	[3]	[3]	[3]	[3]	10.0	13.5	15.2+1.6	7.6
Fungicides only	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	—	[3]

[1] For fungicide treatments only, the unit of subsample was ½ of leaflets 1, 4, 7. The numbers shown in the table are double those found in the counts.
[2] 40+T = 40 wingless aphids + less than 0.5 winged aphids. T is used to denote a trace, or less than 0.5 aphids. The number of winged aphids in this and subsequent tables is always preceded by a plus sign.
[3] Not significant by the F test.

APPENDIX TABLE B

Average Number of Aphids per Plot[1] on the Basis of 25 Plants per Plot, 3 Whole Leaves per Plant, in Experiment 2, 1946

Date	DDT in Bordeaux[2]	DDT in Tribasic copper sulfate	DDT in nabam	DDT in Bordeaux + wetter-spreader	Difference required for significance
	(1)	(2)	(3)	(4)	(P = 0.05)
			Buckthorn aphid		
July 8	12	12 + T	9 + 1	17 + 1	[3]
13	3 + T	7 + 1	13 + 1	4 + T	[3]
15	8 + 1	19 + 1	12 + 1	10 + T	[3]
18	14 + 3	14 + 1	14 + 2	10 + 2	[3]
26	44 + 1	57 + T	66 + 1	47 + 1	[3]
29	90 + 1	122 + 1	241 + 1	73 + 1	[3]
Aug. 1	24 + 2	53 + 2	79 + 2	34 + 2	33.3
5	60 + 5	82 + 3	109 + 5	71 + 4	[3]
12	119 + 3	166 + 2	355 + 2	152 + 1	[3]
15	97 + 21	238 + 18	286 + 17	119 + 19	[3]
22	98 + 6	160 + 5	251 + 5	148 + 7	72.5
31[1]	42 + 3	64 + 1	80 + 4	39 + 2	[3]
Sept. 5[1]	28 + 1	73 + 2	193 + 5	127 + 3	[3]
			Green peach aphid		
July 8	1 + T	0	0	0	[3]
13	0	0	0	T	[3]
15	0	0	0	0	[3]
18	T	0	1	0	[3]
26	T	0	T + T	0	[3]
29	0	T	1	T	[3]
Aug. 1	0	0	0	0	[3]
5	T	0	0	T	[3]
12	T + T	T + T	0	0	[3]
15	3 + 2	5 + 1	3 + 2	1 + 1	[3]
22	23 + 11	25 + 9	25 + 8	23 + 10	[3]
31[1]	7 + 1	1 + 1	1 + 1	6 + 1	[3]
Sept. 5[1]	4 + 1	6 + 1	16 + 1	5 + 1	[3]
			Potato aphid		
July 8	0	1	T	1	[3]
13	1	T	2	0	[3]
15	1	0	0	T	[3]
18	0	1	0	0	[3]
26	1	T	2	1	[3]
29	1	4	4	2	[3]
Aug. 1	1	2	1	1	[3]
5	12	2	7	4	[3]
12	15 + 1	21 + 2	11 + 1	22	[3]
15	10 + 2	13 + 2	9 + 2	15 + 2	[3]
22	34 + 8	51 + 6	41 + 7	48 + 4	[3]
31[1]	19 + 2	22 + 2	29 + 2	21 + 2	[3]
Sept. 5[1]	24 + 2	20 + 3	24 + 3	30 + 3	[3]

[1] On August 31 and September 5 the unit of subsample was leaflets 1, 4, 7 on each of 3 leaves per plant, and on the former date there were but 10 sample units per plot. Data shown in the table for these exceptions are for the indicated number of units and size of subsamples.

[2] See Table 5 for full description of treatments.

[3] Not significant by the F test.

APPENDIX TABLE C

Average Number of Aphids per Plot[1] on the Basis of 25 Plants per Plot, 3 Whole Leaves per Plant, in Experiment 3, 1946

Date	DDT in nabam + usual amount of emulsifier[2] (1)	DDT in tribasic copper sulfate + more emulsifier (2)	DDT in Bordeaux + usual amount of emulsifier (3)	DDT in Bordeaux + more emulsifier (4)	Difference required for significance (P = 0.05)
Buckthorn aphid					
July 8	2	5 + T	5 + T	2 + T	[3]
13	1	T	1	1	[3]
15	1	1	4	1	[3]
18	0	1	2 + T	0	[3]
26	7 + 1	4 + 1	5 + T	2 + T	[3]
29	3	3 + T	3	1	[3]
Aug. 5	47 + 11	41 + 7	39 + 10	21 + 7	[3]
13	229 + 8	163 + 4	216 + 6	154 + 6	[3]
15	259 + 87	154 + 71	127 + 64	147 + 70	[3]
22[1]	186 + 15	156 + 7	144 + 9	135 + 11	[3]
31[1]	89 + 1	47 + 2	50 + 1	26 + 1	[3]
Sept. 5[1]	189 + 7	85 + 2	91 + 2	62 + 4	66.9 + 3.1
Green peach aphid					
July 8	T	0	0	0	[3]
13	0 + T	0	0	0	[3]
15	0	0	0 + T	1 + T	[3]
18	0	0	0	0	[3]
26	0 + T	0	0	0	[3]
29	0	0	0	0	[3]
Aug. 5	1 + 1	1 + 1	0 + T	0 + T	[3]
13	18 + 2	4 + 1	15 + 1	5 + 1	[3]
15	26 + 15	14 + 10	14 + 18	12 + 11	10.2
22[1]	34 + 7	42 + 14	15 + 10	31 + 12	+ 4.4
31[1]	33 + 2	13 + 2	17 + 2	7 + 3	[3]
Sept. 5[1]	42 + 2	22 + 3	17 + 2	6 + 1	22.3
Potato aphid					
July 8	T	T	1	1 + T	[3]
13	0	0	0	0	[3]
15	0	0	0	0	[3]
18	T	0	0	0	[3]
26	1	0	T	0	[3]
29	T	0	0	0	[3]
Aug. 5	3 + 1	3	1	1	[3]
13	36 + 4	28 + 3	54 + 3	45 + 3	[3]
15	23 + 11	19 + 12	21 + 14	17 + 9	[3]
22[1]	46 + 13	38 + 13	36 + 14	35 + 16	[3]
31[1]	42 + 4	25 + 1	20 + 2	14 + 2	[3]
Sept. 5[1]	32 + 2	14 + 2	25 + 6	16 + 2	[3]

[1] On August 22 and 31, and September 5 the unit of subsample was leaflets 1, 4, 7 on each of 3 leaves per plant, and on August 31 there were but 10 sample units per plot. Data shown in the table for these exceptions are for the indicated number of units and size of subsamples.

[2] See Table 8 for full description of treatments.

[3] Not significant by the F test.

APPENDIX TABLE D

Average Number of Aphids per Plot and the Average Percent of Plants Populated by Aphids on the Basis of 25 Plants per Plot, 3 Whole Leaves per Plant, in Experiment 4, 1947

Date	Aromatic solvent No. 3 (1)	Xylene (2)	Alkylated naphthalene No. 1 (3)	Aromatic solvent No. 1 (4)	Alkylated naphthalene No. 2 (5)	Wettable powder (6)	Difference required for significance (P = 0.05)
Aphid population							
Buckthorn aphid							
July 11	1	3 + T	2 + T	2 + T	2	2 + T	1
19	8	4 + T	6	4	7	3	1
25	4	3	3	4	3	7	1
Aug. 1	3 + T	5	3	2 + T	3	7	1
8	7	10 + T	8	7 + T	13	14	1
15	43	67 + T	49	44	63 + T	17	1
21	29 + T	28 + T	40 + T	35 + T	27	29	1
29	15	11 + 1	15	8 + T	23	1 + T	1
Sept. 5	3 + T	3	2 + T	3	2	T	1
11	11	7	5 + 1	8 + 1	15 + 1	3	6.8
17	7 + 1	6 + 1	3 + 1	1 + T	2 + 1	2 + T	1
Green peach aphid							
July 11	0	0	0	0	0	0	1
19	0	0	T	0	0	0	1
25	0	0	0	0	0	0	1
Aug. 1	0	0	0	0	T	0	1
8	0	1 + T	T + T	0	T	T	1
15	1	2	2 + T	1	2	3	1
21	1	2	1	1	1 + T	1	1
29	3	1	T	0	T + T	0 + T	1
Sept. 5	0	0	0 + T	0	T	0	1
11	T	T	1 + T	0	1 + T	0	1
17	T + T	0 + T	0	T	T	0	1
Potato aphid							
July 11	1 + T	1 + T	1	1 + T	1	2	1
19	4	3 + T	3	4	1	5	1
25	4	3 + T	3	1 + T	1 + T	4 + T	1
Aug. 1	2	1	2	1	3	9	3.8
8	1	4	8	6	9	24	8.8
15	23 + 1	23	28 + 1	20 + 1	37 + 1	46 + 1	11.3
21	24 + 1	28 + 1	25 + 1	25 + 1	20 + 1	19 + 1	1
29	7 + 1	6 + 1	9 + 1	5 + 1	4 + 1	2 + 1	2.9
Sept. 5	1 + T	1 + 1	1 + T	T + T	1 + T	0	1
11	6 + 1	7 + 1	7 + 1	6 + 1	7 + 1	5 + 1	1
17	2 + 1	7 + 1	11 + 1	4 + T	6 + 1	6 + 2	1
Foxglove aphid							
July 11	1	0	0	2	0	T	1
19	0	0	0	0	T	0	1
25	0	0	0	0	0	T	1
Aug. 1	0	0	0	0	0	0	1
8	0	T	0	0	0	0	1
15	0	0	0	T	T	0	1
21	1	7 + T	1	T + T	0	T	1
29	0	0	0	T	0	0	1
Sept. 5	0	0	0	T + T	0	0	1
11	0	T	0	0	T	0	1
17	0	0	0	0	0	0	1

APPENDIX TABLE D (Concluded)

Date	Aromatic solvent No. 3 (1)	Xylene (2)	Alkylated naphthalene No. 1 (3)	Aromatic solvent No. 1 (4)	Alkylated naphthalene No. 2 (5)	Wettable powder (6)	Difference required for significance (P = 0.05)
			Percent of plants populated by aphids				
			Buckthorn aphid				
July 11	2.7	4.7	4.7	6.7	3.3	4.0	[1]
19	6.7	6.7	5.3	6.7	5.3	4.7	[1]
25	5.3	4.0	4.7	6.7	6.7	8.7	[1]
Aug. 1	5.3	8.7	6.7	6.0	4.7	10.0	[1]
8	6.0	12.7	10.0	8.7	11.3	12.7	[1]
15	25.3	30.0	28.7	25.3	38.0	20.7	[1]
21	22.0	28.0	24.0	22.7	24.0	13.3	[1]
29	11.3	16.7	16.0	16.7	12.7	4.0	[1]
Sept. 5	8.0	6.7	6.0	6.0	4.7	1.3	[1]
11	14.7	17.3	13.3	16.0	16.7	2.7	7.5
17	7.3	10.7	6.7	5.3	8.7	2.7	[1]
			Green peach aphid				
July 11	0	0	0	0	0	0	[1]
19	0	0	0.7	0	0	0	[1]
25	0	0	0	0	0	0	[1]
Aug. 1	0	0	0	0	1.3	0	[1]
8	0	2.7	2.0	0	0.7	0.7	[1]
15	3.3	4.7	2.0	3.3	6.0	6.7	[1]
21	3.3	4.7	4.7	3.3	2.7	2.0	[1]
29	1.3	2.0	0.7	0	1.3	0.7	[1]
Sept. 5	0	0	0.7	0	0.7	0	[1]
11	1.3	0.7	5.3	0	2.0	0	[1]
17	2.0	0.7	0	1.3	0.7	0	[1]
			Potato aphid				
July 11	2.7	1.3	2.0	2.7	1.3	3.3	[1]
19	4.0	2.0	6.0	4.7	2.0	8.0	[1]
25	4.7	4.0	3.3	4.0	3.3	8.7	[1]
Aug. 1	5.3	2.7	6.7	3.3	7.3	17.3	8.1
8	4.7	11.3	15.3	11.3	18.0	34.0	10.0
15	46.7	46.0	48.7	41.3	55.2	56.0	[1]
21	48.7	48.7	45.3	40.7	42.7	45.3	[1]
29	22.0	19.3	25.3	16.0	12.0	10.0	8.7
Sept. 5	4.0	4.7	4.7	2.0	3.3	0	[1]
11	10.0	11.3	17.3	10.7	14.7	4.7	6.4
17	6.7	16.0	13.3	10.0	9.3	12.0	[1]
			Foxglove aphid				
July 11	2.0	0	0	2.7	0	1.3	[1]
19	0	0	0	0	0.7	0	[1]
25	0	0	0	0	0	0.7	[1]
Aug. 1	0	0	0	0	0	0	[1]
8	0	0.7	0	0	0	0	[1]
15	0	0	0	1.3	0.7	0	[1]
21	1.3	3.3	0.7	1.3	0	0.7	[1]
29	0	0	0	0.7	0	0	[1]
Sept. 5	0	0	0	1.3	0	0	[1]
11	0	0.7	0	0	0.7	0	[1]
17	0	0	0	0	0	0	[1]

[1] Not significant by the F test.

APPENDIX TABLE E

Average Number of Aphids per Plot and the Average Percent of Plants Populated by Wingless Aphids on the Basis of 25 Plants per Plot. 3 Whole Leaves per Plant, in Experiment 4, 1948

Date	Wettable powder (1)	Aromatic solvent No. 1 (2)	Xylene (3)	Aromatic solvent No. 2 (4)	Aromatic solvent No. 3 (5)	Alkylated naphthalene No. 1 (6)	Alkylated naphthalene No. 2 (7)	Difference required for significance (P = 0.05)
Aphid population								
Buckthorn aphid								
June 28[1]	2 ± 1	2 ± 2	1 ± T	1 ± 1	1	T ± T	1 ± T	2
July 7	3 ± 1	3	1 ± T	2 ± 1	3 ± T	2 ± T	T ± 1	2
12	4 ± 1	1	1 ± T	6 ± T	2	3	T	2
19	6	4	2	1	2 ± T	0	0	3.7
26	6	7 ± T	6	3	3 ± T	T	0 ± T	2
Aug. 2	30 ± T	19	8 ± T	20 ± T	10 ± T	10	2 ± T	2
9	39 ± T	35	16 ± T	13	19	21 ± T	6	2
16	89 ± T	19	26 ± 1	26	18	27 ± T	4	2
23	25 ± T	84 ± 1	44 ± T	45 ± T	72 ± T	29 ± 1	25	35.1
30	69 ± 1	90 ± 1	88 ± 2	93 ± 2	37 ± 1	49 ± T	15 ± 1	35.3
Sept. 7	7 ± T	10 ± T	7	33	6	17	3	2
13	16 ± T	15 ± 1	10 ± T	61 ± 2	9 ± 1	7 ± 1	9 ± 1	2
Green peach aphid								
June 28[1]	0	0	0	0	0	0	0	2
July 7	0	0	0	0	0	0	0	2
12	0	0	0	0	0	0	0	2
19	0	0	0	0	0	0	0	2
26	0	0	0	0	0	0	0	2
Aug. 2	0	T	0	0	0	0	0 ± T	2
9	T	0	0	0	0	0	0 ± T	2
16	T	0	0	0	2	T	0	2
23	T	T	1	T	1	1	T	2
30	1 ± T	2 ± 1	1	2 ± T	2 ± T	1 ± 1	2	2
Sept. 7	T ± T	T	T	0	0	1	T	2
13	0	1	T	T	T	0	T	2
Potato aphid								
June 28[1]	3 ± T	T	T	1 ± 1	2 ± T	1 ± 1	T	2
July 7	T	1	T	1	1	2	1 ± T	2
12	0 ± T	T	T	1	2 ± T	T	T	2
19	1	2	T	2 ± T	1 ± T	T	0	2
26	T	T	T	1	T ± T	0 ± T	T	2
Aug. 2	4 ± T	1	1	T	2	2 ± T	2	2
9	7 ± 1	6 ± 1	1 ± T	3 ± T	4 ± T	2	2 ± T	2
16	18 ± 1	8	5 ± T	6 ± 1	4 ± 1	13 ± 1	4 ± 1	7.2
23	52 ± 1	19 ± T	30 ± 1	27 ± 1	36 ± 1	39 ± T	35 ± 2	2
30	91 ± 4	58 ± 2	71 ± 3	55 ± 2	73 ± 3	82 ± 1	78 ± 2	2
Sept. 7	9 ± 1	11 ± 1	12 ± 1	16 ± 1	14 ± T	12 ± 1	10 ± 1	2
13	37 ± 6	27 ± 4	38 ± 5	44 ± 4	19 ± 2	25 ± 3	25 ± 3	2
Foxglove aphid								
June 28[1]	T ± T	2 ± T	1 ± 1	2 ± T	1 ± T	1 ± T	T ± T	2
July 7	1 ± T	1 ± T	3 ± T	2 ± T	2 ± T	2	1 ± T	2
12	3 ± T	1 ± T	1	1	1 ± T	T	T	2
19	2	1	T	1 ± T	T	T	0	2
26	0	T	4 ± T	0	0	T	0	2.2
Aug. 2	0 ± T	1	6 ± T	1	2	1	0	2
9	0	T	3	0	T	0	T	2
16	0	0	0	1 ± T	0	0	0	2
23	0	0	0	0	0	0	T	2
30	0	T	0	T	0	T	0	2
Sept. 7	0	0	0	0	0	0	0	2
13	0	0	0	0	0	0	0	2

APPENDIX TABLE E (Concluded)

Date	Wettable powder (1)	Aromatic solvent No. 1 (2)	Xylene (3)	Aromatic solvent No. 2 (4)	Aromatic solvent No. 3 (5)	Alkylated naphthalene No. 1 (6)	Alkylated naphthalene No. 2 (7)	Difference required for significance (P = 0.05)
				Percent of plants populated by wingless aphids				
				Buckthorn aphid				
June 28[1]	3.2	4.0	2.4	2.4	4.0	1.6	1.6	[2]
July 7	4.8	9.6	0.8	5.6	6.4	5.6	1.6	[2]
12	8.8	4.0	2.4	6.4	2.4	4.8	1.6	[2]
19	8.0	8.0	3.2	2.4	4.8	0	0	4.9
26	8.8	6.4	5.6	4.0	3.2	0.8	0.8	5.0
Aug. 2	20.8	15.2	12.8	13.6	9.6	11.2	3.2	9.7
9	20.0	18.4	16.0	12.8	10.4	5.6	6.4	[2]
16	22.4	16.0	18.4	16.8	11.2	11.2	4.0	10.0
23	23.2	30.4	20.8	27.2	24.8	16.0	9.6	[2]
30	34.4	31.2	28.8	31.2	23.2	24.8	13.6	[2]
Sept. 7	15.2	11.2	9.6	20.8	8.8	12.0	8.0	[2]
13	13.6	8.0	9.6	20.0	8.0	12.8	6.4	[2]
				Green peach aphid				
June 28[1]	0	0	0	0	0	0	0	[2]
July 7	0	0	0	0	0	0	0	[2]
12	0	0	0	0	0	0	0	[2]
19	0	0	0	0	0	0	0	[2]
26	0	0	0	0	0	0	0	[2]
Aug. 2	0	0.8	0	0	0	0	0	[2]
9	0.8	0	0	0	0	0	0	[2]
16	0.8	0	0	0	0.8	0.8	0	[2]
23	1.6	1.6	4.0	0.8	3.2	2.4	1.6	[2]
30	2.4	4.8	2.4	4.8	8.0	3.2	4.0	3.1
Sept. 7	1.6	0.8	0.8	0	0	1.6	0.8	[2]
13	0	4.0	1.6	0.8	1.6	0	0.8	1.9
				Potato aphid				
June 28[1]	5.6	1.6	1.6	3.2	4.0	4.0	0.8	[2]
July 7	0.8	5.6	1.6	5.6	4.0	5.6	4.8	[2]
12	0	1.6	0.8	2.4	2.4	0.8	0.8	[2]
19	1.6	4.0	1.6	1.6	0.8	1.6	0	[2]
26	0.8	1.6	0.8	1.6	1.6	0	1.6	[2]
Aug. 2	10.4	5.6	0.8	1.6	4.8	3.2	3.2	[2]
9	15.2	7.2	4.0	4.8	5.6	4.8	6.4	6.4
16	34.4	15.2	10.4	13.6	11.2	16.8	12.8	13.2
23	57.6	33.6	37.6	43.2	46.4	49.6	42.4	[2]
30	71.2	66.4	64.0	66.4	68.0	72.0	73.6	[2]
Sept. 7	22.4	26.4	21.6	28.0	24.0	31.2	19.2	[2]
14	36.8	37.6	36.0	48.8	32.0	43.2	37.6	[2]
				Foxglove aphid				
June 28[1]	1.6	2.4	3.2	4.8	2.4	1.6	0.8	[2]
July 7	2.4	3.2	3.2	5.6	3.2	5.6	3.2	[2]
12	5.6	1.6	2.4	3.2	4.0	0.8	0.8	3.1
19	3.2	0.8	1.6	2.4	1.6	0.8	0	[2]
26	0	0.8	4.0	0	0	0.8	0	2.1
Aug. 2	0	1.6	4.0	2.4	2.4	2.4	0	[2]
9	0	1.6	3.2	0	0.8	0	0.8	[2]
16	0	0	0	0.8	0	0	0	[2]
23	0	0	0	0	0	0	1.6	[2]
30	0	0.8	0	0.8	0	0.8	0	[2]
Sept. 7	0	0	0	0	0	0	0	[2]
14	0	0	0	0	0	0	0	[2]

[1] On June 28 the unit was the whole plant.
[2] Not significant by the F test.